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Hasebe et al.

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(54) **DRYING DEVICE AND IMAGE FORMING APPARATUS**

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(51) **Int. Cl.**
B41J 11/00 (2006.01)

(52) **U.S. Cl.**
CPC ***B41J 11/002*** (2013.01); *B41J 11/0015* (2013.01)

(58) **Field of Classification Search**
CPC .. B41J 11/002; B41J 11/0005; B41J 11/0015; B41M 7/0081; C09D 11/101; C09D 11/30
See application file for complete search history.

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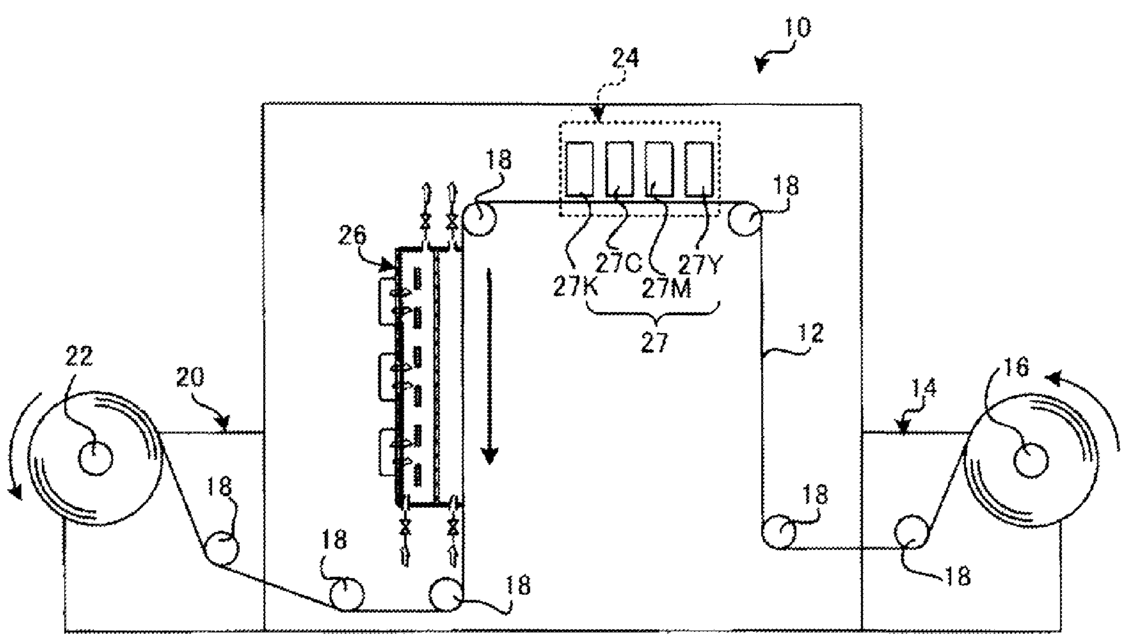
(57) **ABSTRACT**

A drying device includes: a drying unit including: a heating space having a heating unit; a drying space that has a conveyance path of a recording medium and in which the recording medium is dried by radiation heat produced by the heating unit; and a partition member that separates the heating space and the drying space from each other in such a manner that gas can move between the heating space and the drying space; a first supply unit that supplies gas to the drying unit in a direction that is opposite to a conveying direction of the recording medium; and a second supply unit that supplies gas to the drying unit in a direction from the heating unit to the partition member.

18 Claims, 12 Drawing Sheets



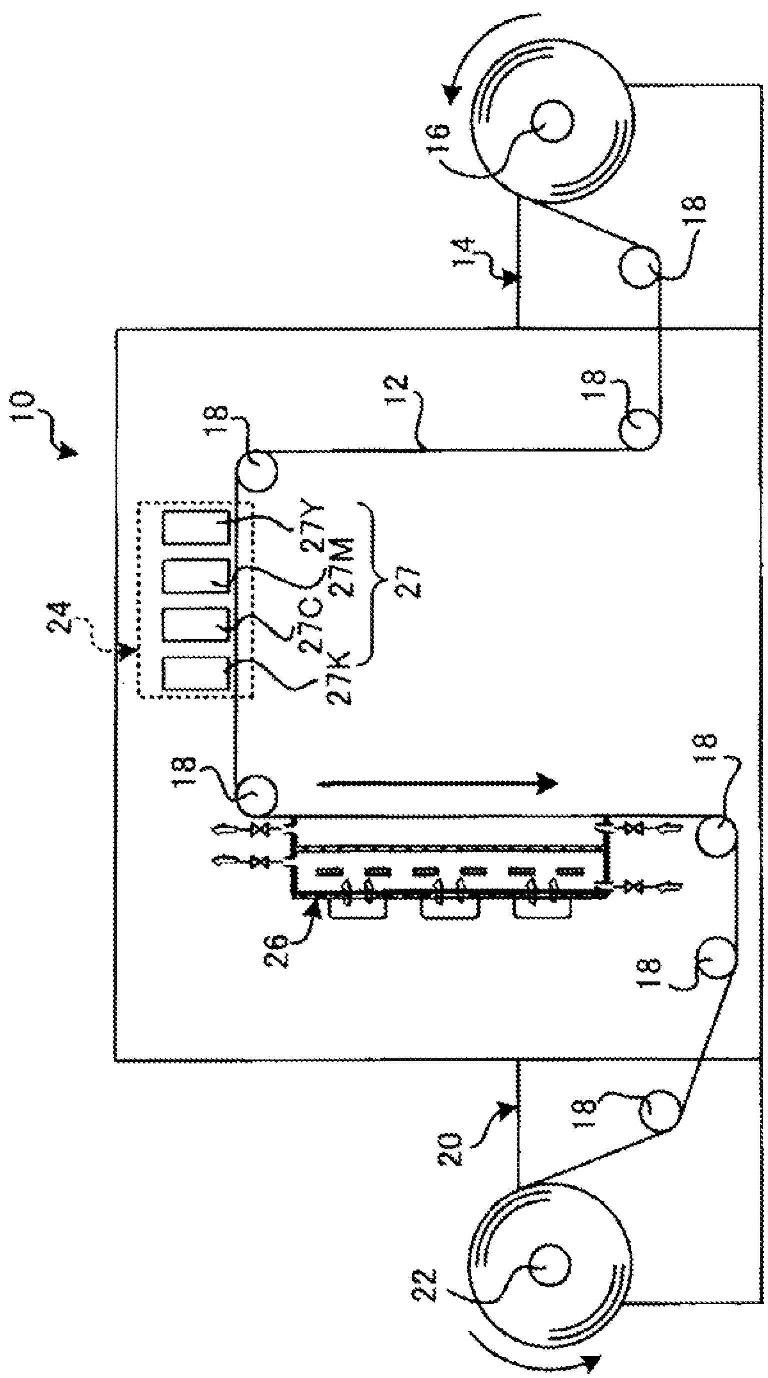
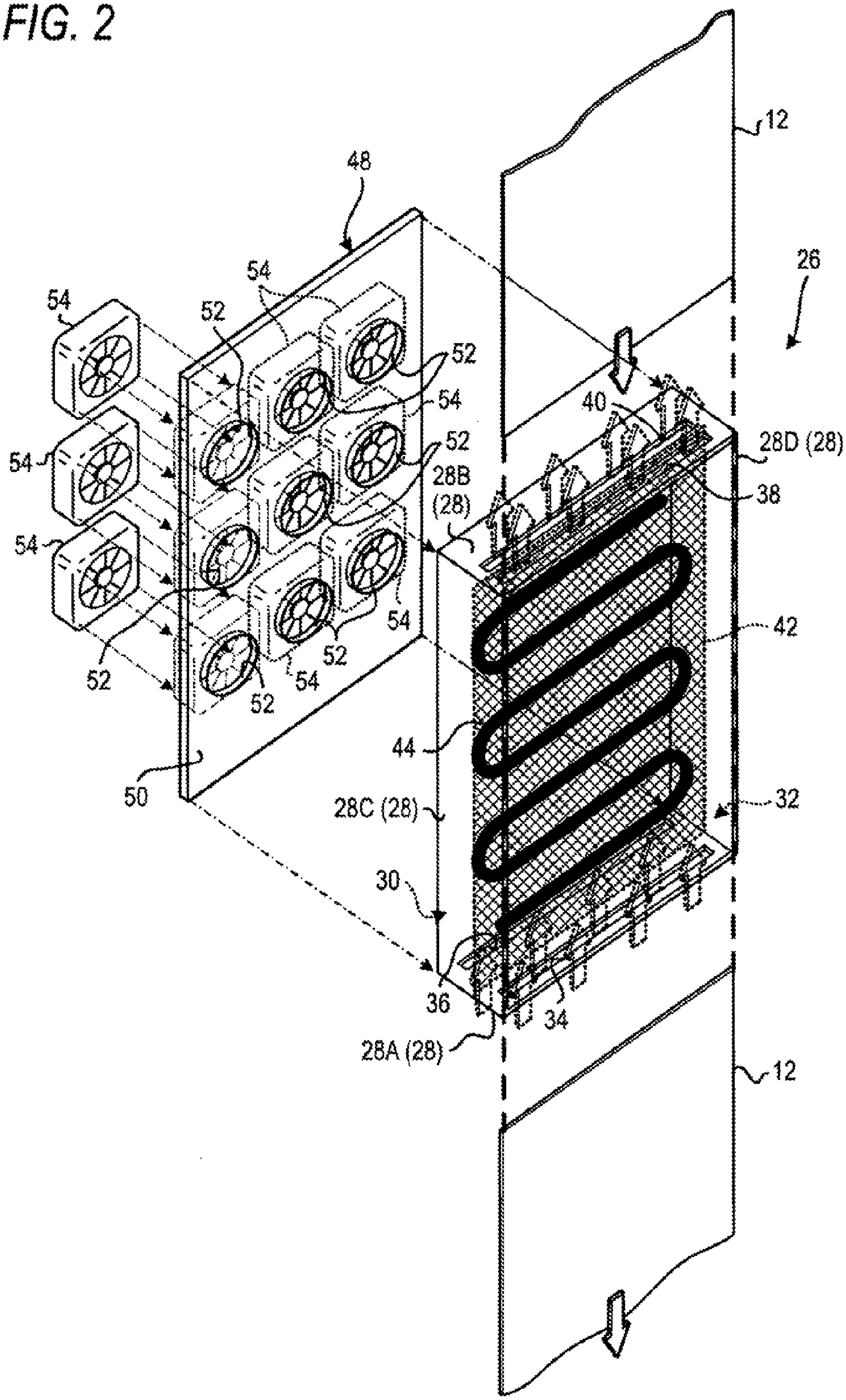


FIG. 1

FIG. 2


12
48
26
54
54
52
52
54
40
28D (28)
54
52
38
28B
(28)
54
54
52
42
52
54
52
54
44
50
28C (28)
32
30
36
34
28A (28)
12

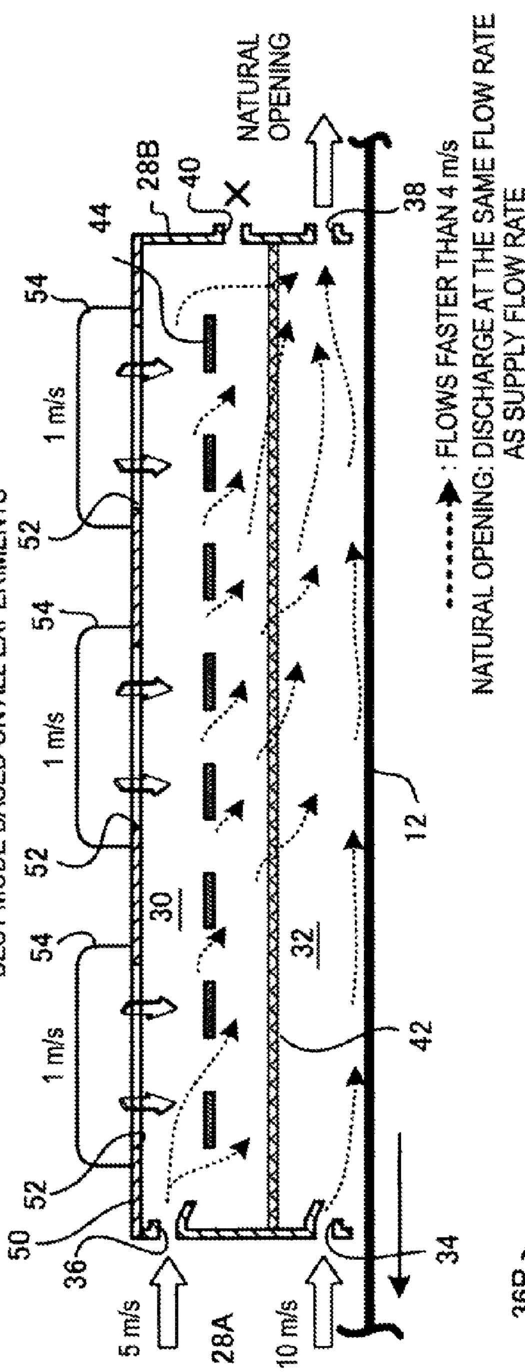

BEST MODE BASED ON ALL EXPERIMENTS
1 m/s
1 m/s
1 m/s
5 m/s
10 m/s
NATURAL OPENING
: FLOWS FASTER THAN 4 m/s
NATURAL OPENING: DISCHARGE AT THE SAME FLOW RATE AS SUPPLY FLOW RATE
50
52
54
36
28A
34
30
32
42
12
44
28B
40
38

FIG. 3A

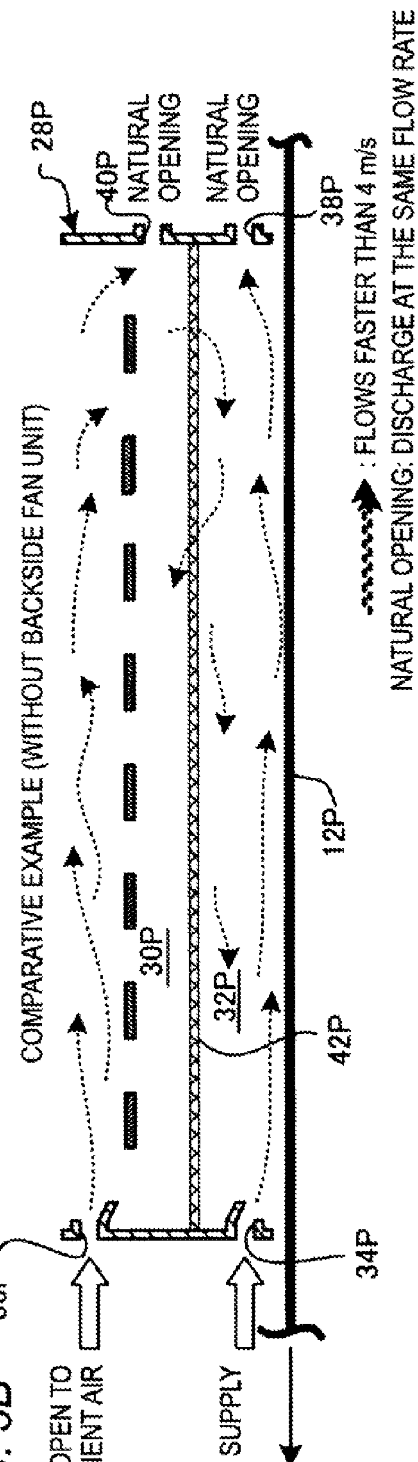

COMPARATIVE EXAMPLE (WITHOUT BACKSIDE FAN UNIT)
OPEN TO AMBIENT AIR
AIR SUPPLY
NATURAL OPENING
NATURAL OPENING
: FLOWS FASTER THAN 4 m/s
NATURAL OPENING: DISCHARGE AT THE SAME FLOW RATE AS SUPPLY FLOW RATE
36P
34P
30P
32P
42P
12P
28P
40P
38P

FIG. 3B

FIG. 4A

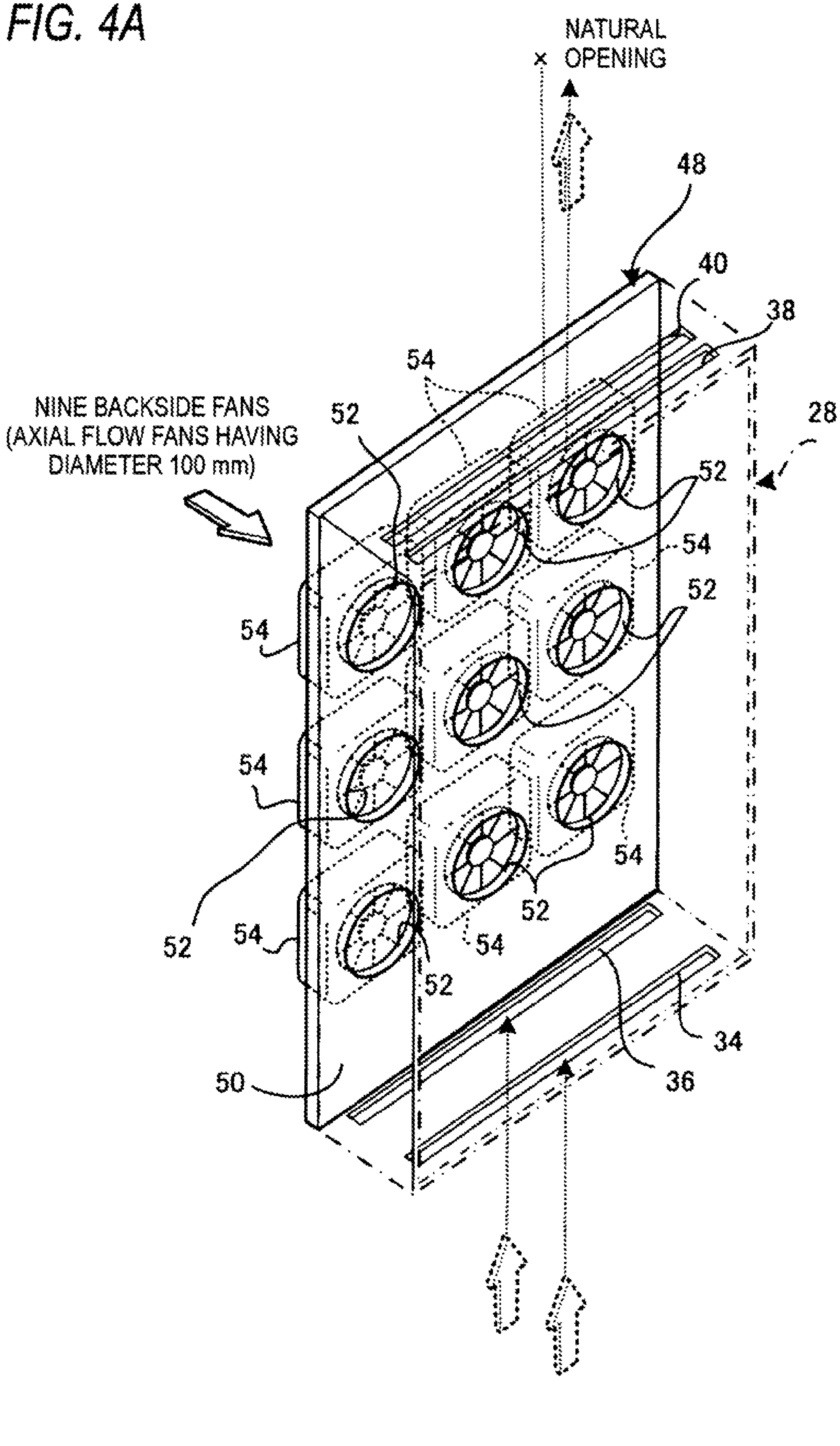

NATURAL OPENING
NINE BACKSIDE FANS (AXIAL FLOW FANS HAVING DIAMETER 100 mm)
48
40
38
54
52
28
52
54
52
54
54
52
54
52
54
52
52
54
52
50
34
36

FIG. 4B

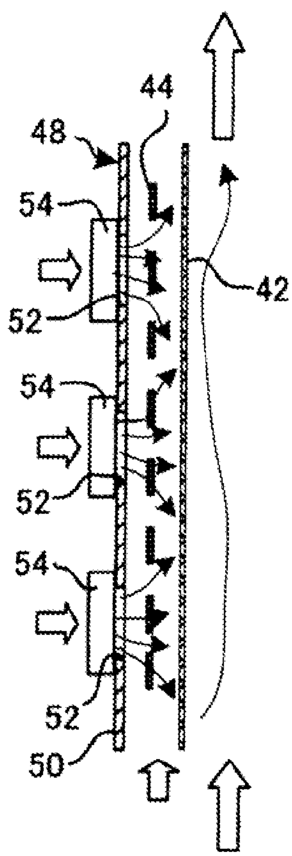


FIG. 4C

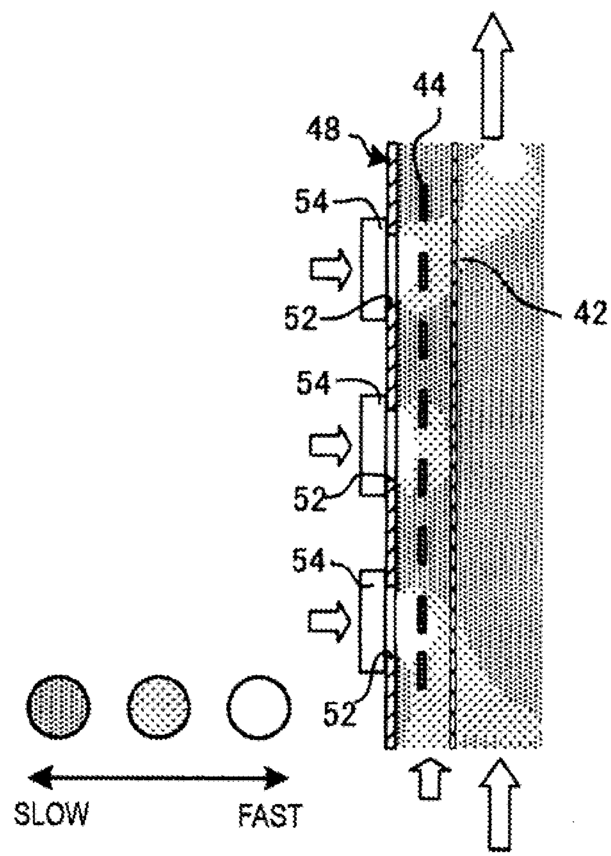


FIG. 5A

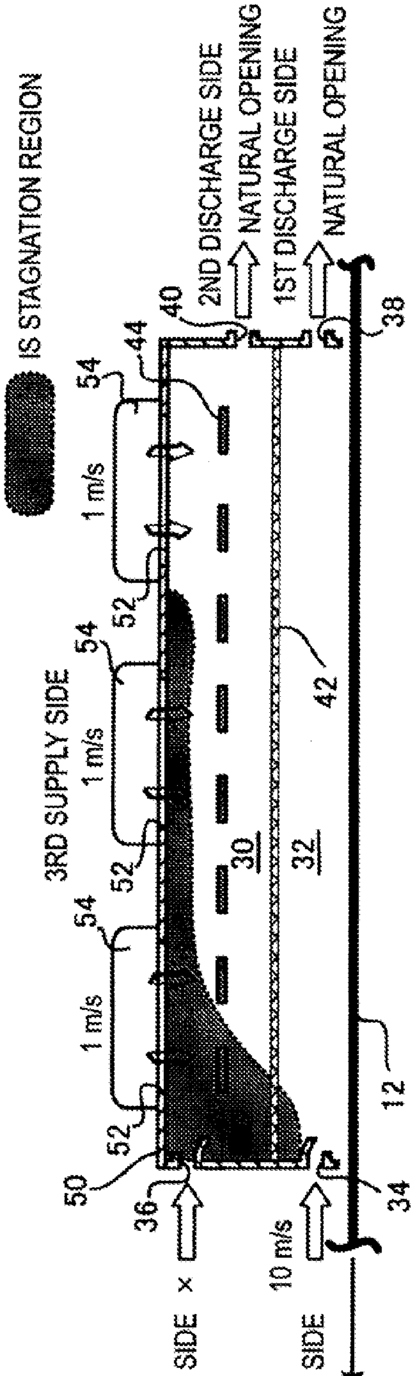
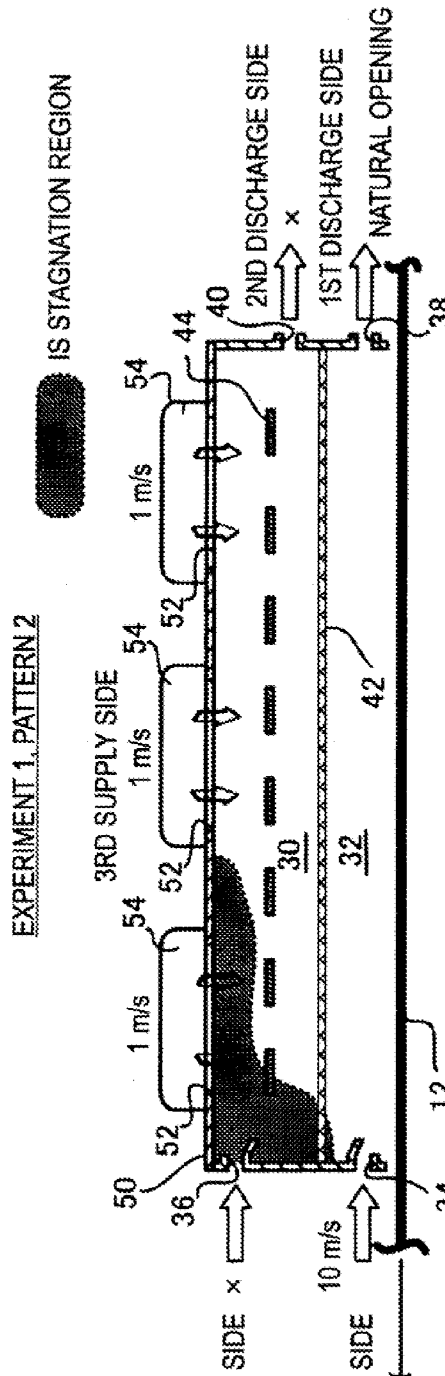

EXPERIMENT 1, PATTERN 1
IS STAGNATION REGION
3RD SUPPLY SIDE
1 m/s
1 m/s
1 m/s
2ND SUPPLY SIDE ×
1ST SUPPLY SIDE
10 m/s
2ND DISCHARGE SIDE
NATURAL OPENING
1ST DISCHARGE SIDE
NATURAL OPENING
50
36
34
52
54
30
32
42
12
44
40
38

FIG. 5B


EXPERIMENT 1, PATTERN 2
IS STAGNATION REGION
3RD SUPPLY SIDE
1 m/s
1 m/s
1 m/s
2ND SUPPLY SIDE ×
1ST SUPPLY SIDE
10 m/s
2ND DISCHARGE SIDE
×
1ST DISCHARGE SIDE
NATURAL OPENING
50
36
34
52
54
30
32
42
12
44
40
38

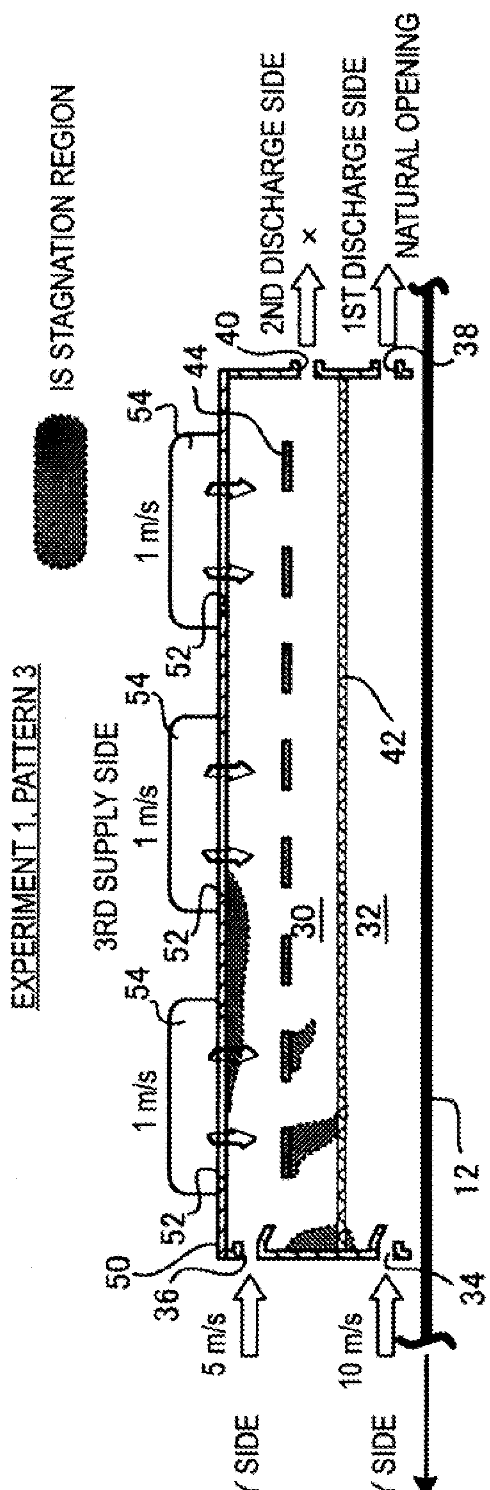

EXPERIMENT 1, PATTERN 3
IS STAGNATION REGION
2ND SUPPLY SIDE
1ST SUPPLY SIDE
3RD SUPPLY SIDE
2ND DISCHARGE SIDE
×
1ST DISCHARGE SIDE
NATURAL OPENING
5 m/s
10 m/s
1 m/s
1 m/s
1 m/s
50
36
52
54
52
54
52
54
44
40
30
32
42
12
34
38

FIG. 5C

FIG. 6A

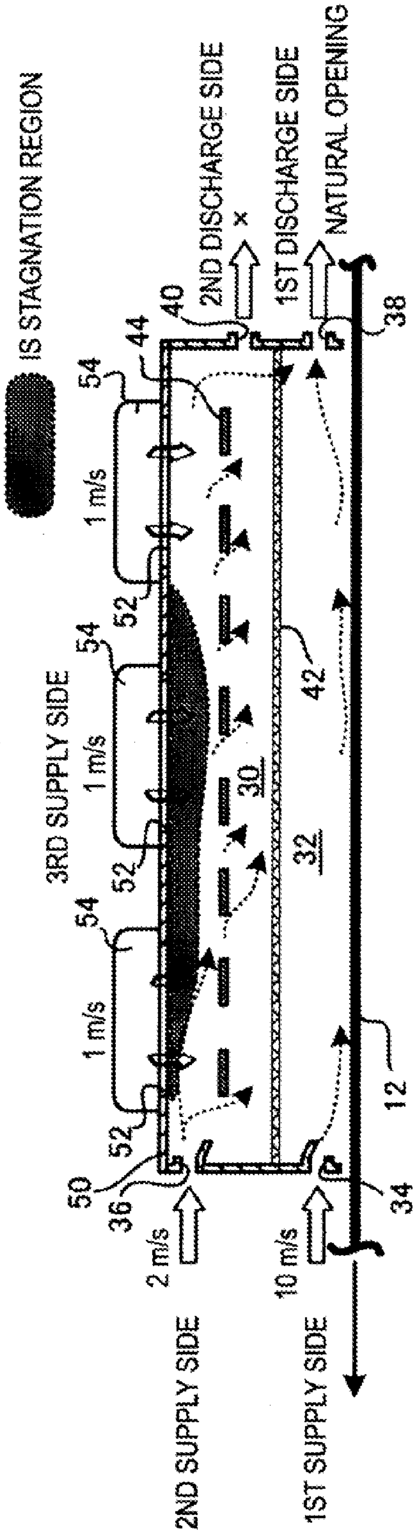
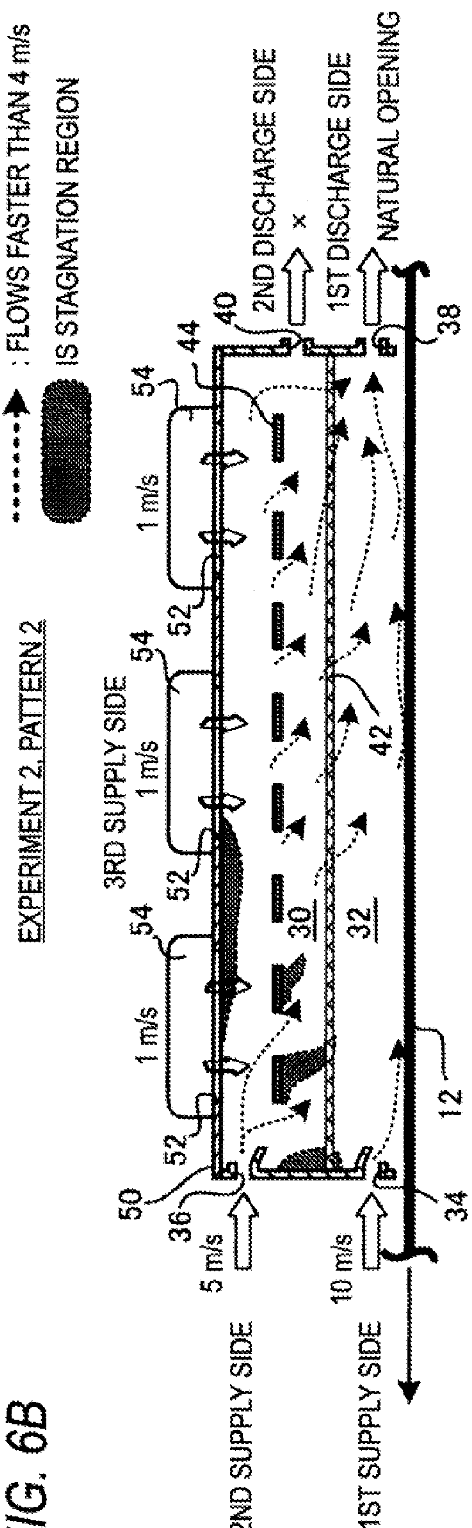

EXPERIMENT 2, PATTERN 1
: FLOWS FASTER THAN 4 m/s
IS STAGNATION REGION
3RD SUPPLY SIDE
1 m/s
1 m/s
1 m/s
2ND DISCHARGE SIDE
×
1ST DISCHARGE SIDE
NATURAL OPENING
2ND SUPPLY SIDE
1ST SUPPLY SIDE
2 m/s
10 m/s
50
36
52
54
44
40
38
34
12
42
30
32

FIG. 6B


EXPERIMENT 2, PATTERN 2
: FLOWS FASTER THAN 4 m/s
IS STAGNATION REGION
3RD SUPPLY SIDE
1 m/s
1 m/s
1 m/s
2ND DISCHARGE SIDE
×
1ST DISCHARGE SIDE
NATURAL OPENING
2ND SUPPLY SIDE
1ST SUPPLY SIDE
5 m/s
10 m/s
50
36
52
54
44
40
38
34
12
42
30
32

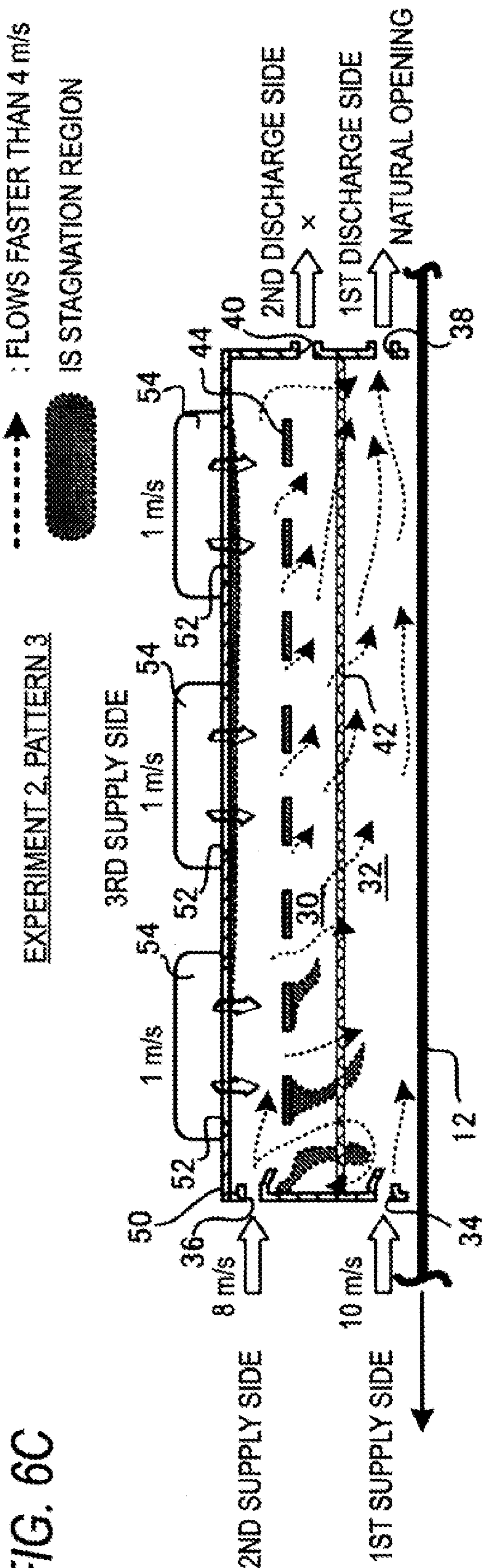

EXPERIMENT 2, PATTERN 3
: FLOWS FASTER THAN 4 m/s
IS STAGNATION REGION
2ND SUPPLY SIDE
1ST SUPPLY SIDE
3RD SUPPLY SIDE
2ND DISCHARGE SIDE
×
1ST DISCHARGE SIDE
NATURAL OPENING
8 m/s
10 m/s
1 m/s
1 m/s
1 m/s
12
30
32
34
36
38
40
42
44
50
52
54

FIG. 6C

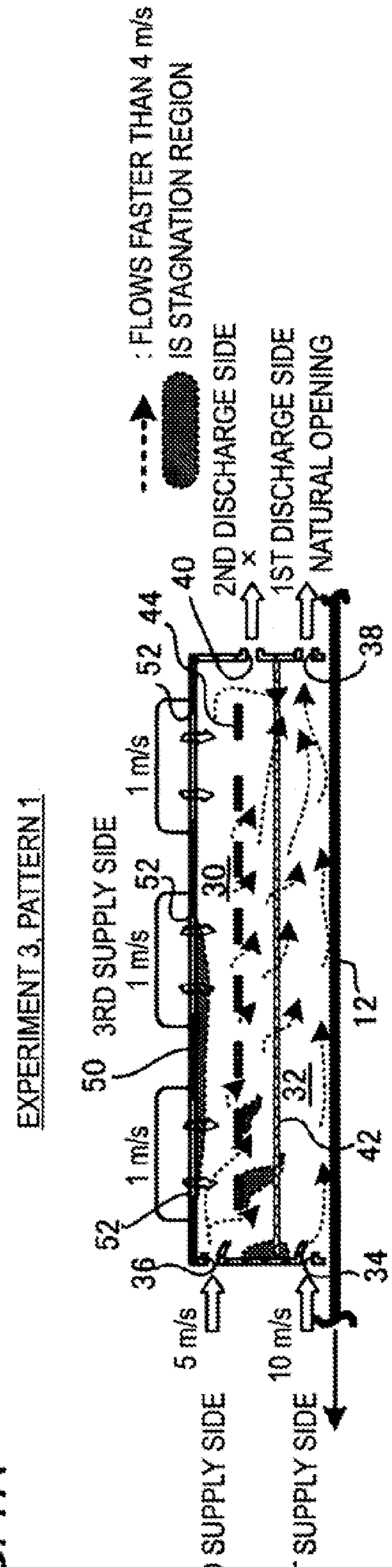

EXPERIMENT 3, PATTERN 1
3RD SUPPLY SIDE
1 m/s
1 m/s
1 m/s
50
52
52
52
44
40
30
32
12
42
34
36
38
5 m/s
10 m/s
2ND SUPPLY SIDE
1ST SUPPLY SIDE
2ND DISCHARGE SIDE
×
1ST DISCHARGE SIDE
NATURAL OPENING
: FLOWS FASTER THAN 4 m/s
IS STAGNATION REGION

FIG. 7A

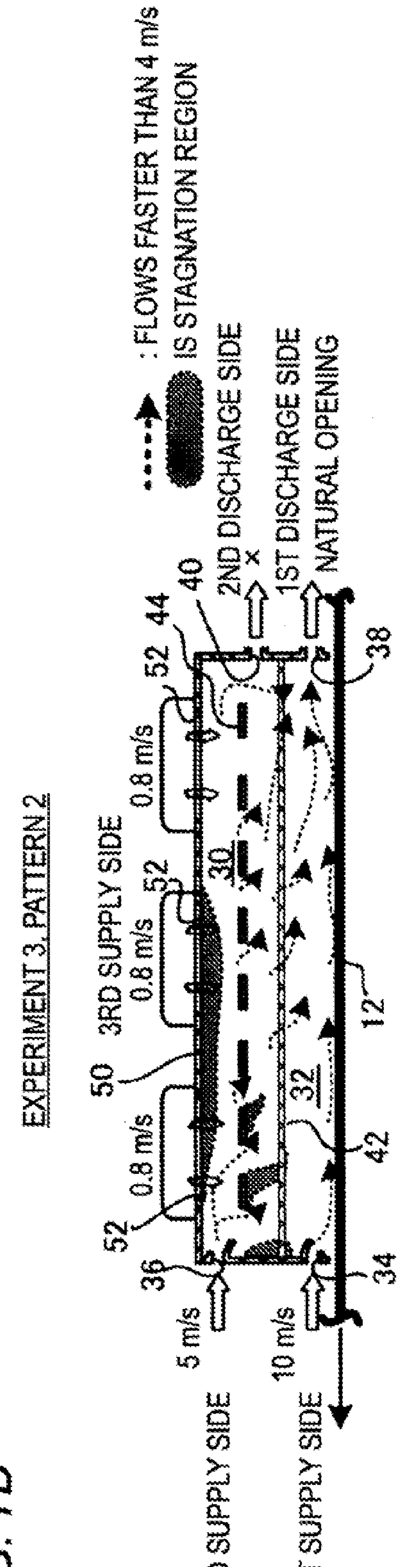

EXPERIMENT 3, PATTERN 2
3RD SUPPLY SIDE
0.8 m/s
0.8 m/s
0.8 m/s
50
52
52
52
44
40
30
32
12
42
34
36
38
5 m/s
10 m/s
2ND SUPPLY SIDE
1ST SUPPLY SIDE
2ND DISCHARGE SIDE
×
1ST DISCHARGE SIDE
NATURAL OPENING
: FLOWS FASTER THAN 4 m/s
IS STAGNATION REGION

FIG. 7B

FIG. 7C

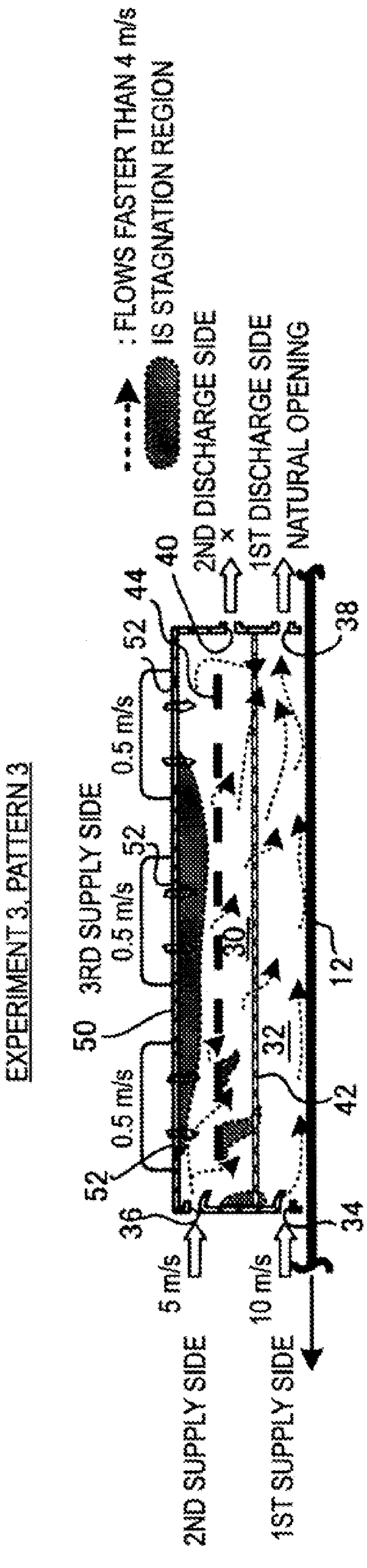

EXPERIMENT 3, PATTERN 3
3RD SUPPLY SIDE
0.5 m/s
0.5 m/s
0.5 m/s
0.5 m/s
52
52
52
50
44
40
30
32
42
12
36
34
38
5 m/s
10 m/s
2ND SUPPLY SIDE
1ST SUPPLY SIDE
2ND DISCHARGE SIDE
×
1ST DISCHARGE SIDE
NATURAL OPENING
: FLOWS FASTER THAN 4 m/s
IS STAGNATION REGION

FIG. 7D

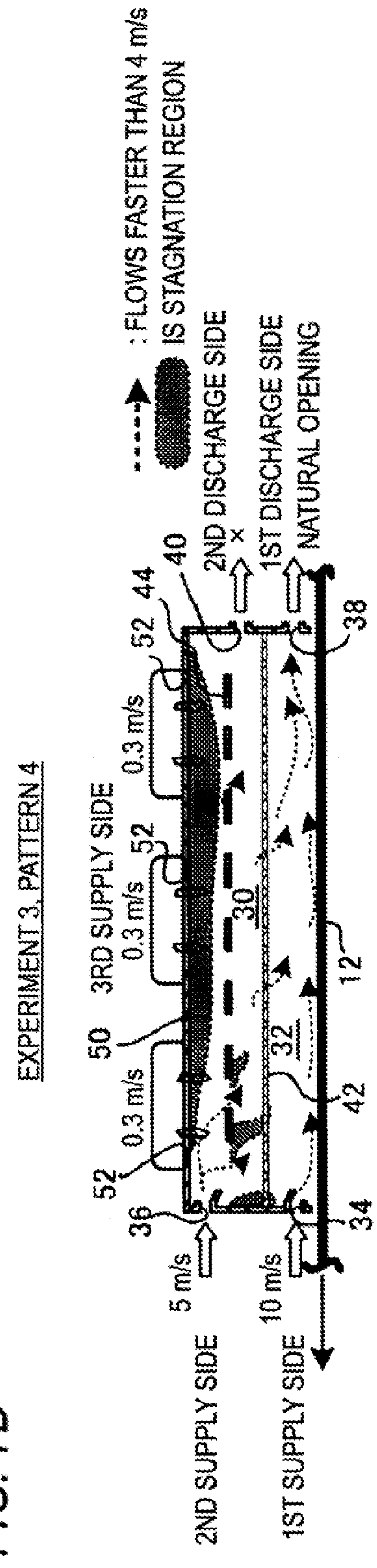

EXPERIMENT 3, PATTERN 4
3RD SUPPLY SIDE
0.3 m/s
0.3 m/s
0.3 m/s
0.3 m/s
52
52
52
50
44
40
30
32
42
12
36
34
38
5 m/s
10 m/s
2ND SUPPLY SIDE
1ST SUPPLY SIDE
2ND DISCHARGE SIDE
×
1ST DISCHARGE SIDE
NATURAL OPENING
: FLOWS FASTER THAN 4 m/s
IS STAGNATION REGION

FIG. 8A

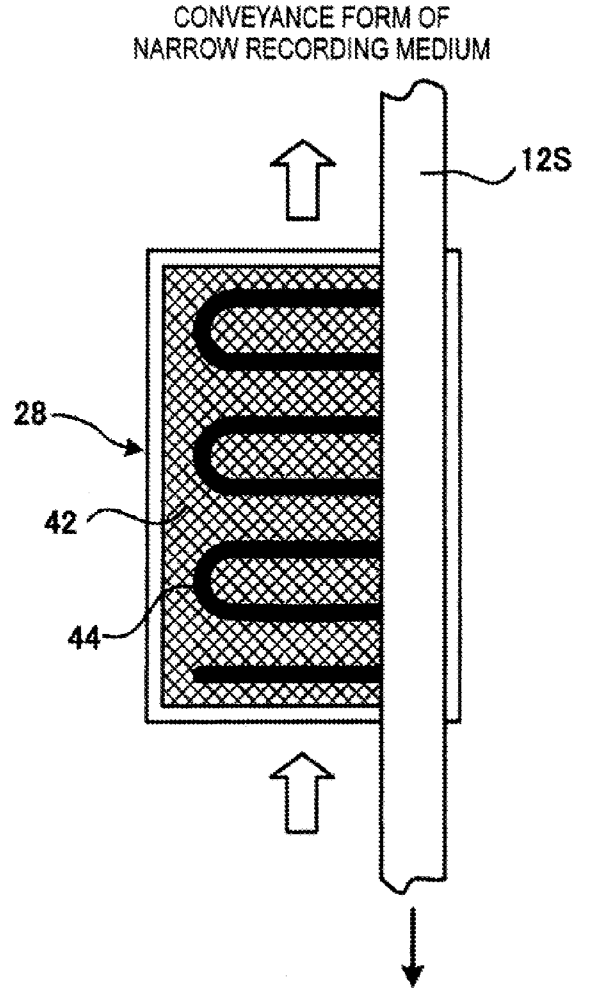


FIG. 8B

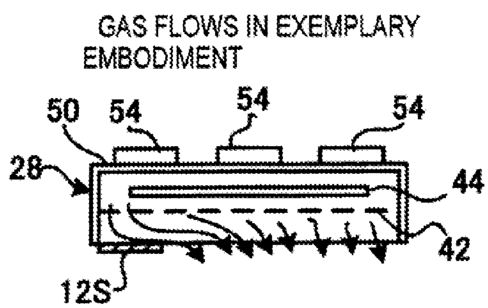
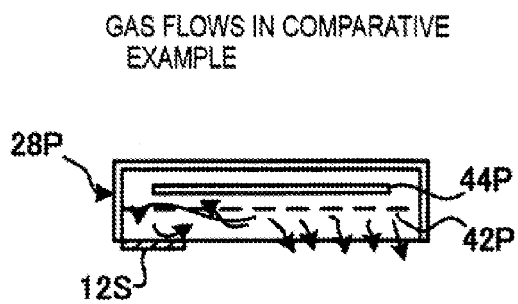


FIG. 8C



DRYING DEVICE AND IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority under 35 USC 119 from Japanese Patent Application No. 2014-043243 filed on Mar. 5, 2014.

BACKGROUND

Technical Field

The present invention relates to a drying device and an image forming apparatus.

SUMMARY

According to an aspect of the invention, there is provided a drying device comprising: a drying unit comprising: a heating space having a heating unit; a drying space that has a conveyance path of a recording medium and in which the recording medium is dried by radiation heat produced by the heating unit; and a partition member that separates the heating space and the drying space from each other in such a manner that gas can move between them; a first supply unit that supplies gas to the drying unit in a direction that is opposite to a conveying direction of the recording medium; and a second supply unit that supplies gas to the drying unit in a direction from the heating unit to the partition member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a general configuration of an image recording apparatus according to an exemplary embodiment.

FIG. **2** is an exploded perspective view of a drying unit according to the exemplary embodiment.

FIG. **3**A is a (rotated) vertical sectional view of the drying unit in which opening/closure of inlets and blowing holes and flow rates of drying winds are set in preferable manners, and FIG. **3**B is a vertical sectional view of a drying unit of Comparative Example.

FIG. **4**A is a perspective view of a backside fan unit which is provided in the drying unit, FIG. **4**B shows stream line of drying winds produced by the backside fan unit, and FIG. **4**C is a chart showing a drying wind flow speed distribution characteristic of the backside fan unit.

FIGS. **5**A, **5**B and **5**C are (rotated) vertical sectional views of the drying unit in Patterns 1, 2 and 3 of Experiment 1, respectively.

FIGS. **6**A, **6**B and **6**C are (rotated) vertical sectional views of the drying unit in Patterns 1-3 of Experiment 2, respectively.

FIGS. **7**A, **7**B, **7**C and **7**D are (rotated) vertical sectional views of the drying unit in Patterns 1, 2, 3 and 4 of Experiment 3, respectively.

FIG. **8**A is a front view of the drying unit in a case that a narrow recording medium is conveyed, FIG. **8**B is a horizontal sectional view of the drying unit according to the exemplary embodiment which is equipped with the backside fans and shows stream line in a case that a narrow recording medium is conveyed, and FIG. **8**C is a horizontal sectional view of the drying unit of Comparative Example which is equipped with the backside fans and shows stream line in a case that a narrow recording medium is conveyed.

DESCRIPTION OF SYMBOLS

10: Image recording apparatus
12: Recording medium
14: Sheet supply unit
16: Sheet supply roller
18: Relay roller
20: Housing unit
22: Takeup roller
24: Image forming unit
26: Drying unit
27 (**27**Y, **27**M, **27**C, **27**K): Inkjet head
28: Main frame body
28A: First wall
28B: Second wall
28C: Third wall
28D: Fourth wall
30: Heating space
32: Drying space
34, **36**: Inlet
38: **40**: Outlet
42: Wire gauze (partition member)
44: Heater unit
48: Backside fan unit
50: Base member
52: Blowing hole
54: Backside fan

DETAILED DESCRIPTION

FIG. **1** outlines an inkjet image recording apparatus **10** (hereinafter referred to simply as an image recording apparatus **10**) which is an image forming apparatus according to the present invention. In the image recording apparatus **10** according to the exemplary embodiment, an image is recorded (printed) by ejecting inks onto a recording medium **12** by an inkjet method and is then dried.

As shown in FIG. **1**, the recording medium **12** is loaded in a sheet supply unit **14** in advance in such a manner as to be wound around a sheet supply roller **16** in layers. Part of the recording medium **12** that has been paid out from the sheet supply roller **16** is wound on plural relay rollers **18** and wound around a takeup roller **22** of a housing unit **20**. A motor (not shown) is attached to the takeup roller **22** rotates it in taking up part of the recording medium **12**. That is, the takeup roller **22** is a drive roller and the other rollers are follower rollers.

Another mechanism is possible in which a motor is attached to the sheet supply roller **16** or the relay rollers **18** to make it or them a drive roller(s) and a paid-out part of the recording medium **12** is taken up while tension of a part of the recording medium **12** between each pair of adjoining rollers is adjusted. In this case, position sensors or tension sensors for detecting loosening of the recording medium **12** may be provided and the rotation speed (and the rotation direction) of the drive roller(s) may be controlled by a feedback control.

As shown in FIG. **1**, a region where a part of the recording medium **12** is conveyed horizontally and straightly is provided between a pair of relay rollers **18** and an image forming unit **24** is disposed there. A region where a part of the recording medium **12** is conveyed vertically and straightly is provided between another pair of relay rollers **18** downstream of the image forming unit **24** and a drying unit **26** is disposed there.

Inkjet heads **27**Y, **27**M, **27**C, and **27**K of Y (yellow), M (magenta), C (cyan), and K (black) are arranged in the image forming unit **24** and may be referred to generically as an inkjet head(s) **27** below. Ink that is stored in an ink cassette, for example, is brought into each ink head **27** and ink droplets are ejected out of nozzles toward a part of the recording medium **12** opposed to the nozzles by a pressure control, an ultrasonic control, or the like.

In the image recording apparatus **10** according to the exemplary embodiment, the nozzles are arranged so as to cover the entire length of the recording medium **12** in the main scanning direction and the inkjet heads **27** of the respective colors are arranged in the auxiliary scanning direction of the recording medium **12**. Ink droplets of amounts corresponding to image data are ejected out of the nozzles of each inkjet head **27** in synchronism with conveyance of the recording medium **12**. The manners of arrangement of the nozzles and the inkjet heads **27** are not limited to the above ones; a configuration is possible in which each inkjet head **27** is moved in the main scanning direction.

In the drying unit **26**, a part of the recording medium **12** on which an image has been formed by the image forming unit **24** is conveyed downward (as viewed in FIG. **1**). As the recording medium **12** is conveyed, image-formed surface portions are sequentially placed in the drying region.

FIG. **2** is an exploded perspective view of the drying unit **26**. The drying unit **26** is equipped with a main frame body **28** having four walls. That is, having top and bottom (as viewed in FIG. **2**) parallel plates and left and right parallel plates, the main frame body **28** assume a rectangular parallelepiped shape.

In the following description of the exemplary embodiment, the orientation of the drying unit **26** varies depending on the drawing. Therefore, in the following, the bottom plate, top plate, left plate, and right plate of the main frame body **28** as viewed in FIG. **2** will be referred to as a first wall **28**A, second wall **28**B, third wall **28**C, and fourth wall **28**D, respectively.

Two drying wind inlets **34** and **36** are formed through the first wall **28**A so as to communicate with the inside space (drying space **32** and heating space **30** (described later)) of the main frame body **28**. The drying wind inlets **34** and **36** extend in the longitudinal direction of the first wall **28**A and shaped like slits. The drying wind inlets **34** and **36** are provided with ducts (not shown) through which to supply gas (air) independently. Therefore, gas can be supplied to the inside space through the inlets **34** and **36** at different flow speeds.

Two gas outlets **38** and **40** are formed through the second wall **28**B so as to communicate with the inside space of the main frame body **28**. The outlets **38** and **40** extend in the longitudinal direction of the second wall **28**B and shaped like slits. The outlets **38** and **40** are provided with ducts (not shown) for gas discharge. The ducts are provided independently for the outlets **38** and **40** and a suction pump (not shown) is attached to them. However, in calculations, natural opening may be similar in performance to pump suction. Although the exemplary embodiment actually employs pump suction rather than natural opening, the term "natural opening" includes a case that natural opening is employed in a calculation. The outlets **38** and **40** can be opened or closed selectively.

A net member (in the exemplary embodiment, a wire gauze **42**) which is a partition member is disposed in the main frame body **28** so as to partition its inside space. The dimensions of the wire gauze **42** correspond to the inner dimensions of the main frame body **28**, and its circumferential edges are fixed to the inner surfaces of the main frame body **28** (i.e., the inner surfaces of the first to fourth walls **28**A-**28**D). No limitations are imposed on the method for fixing the wire gauze **42**; it may be any of various fixing methods such as fitting into grooves formed in the inner surfaces of the main frame body **28**, fixing via brackets, and fixing with adhesive.

The wire gauze **42** is required to be heat-resistant and it is preferable that it be made of a metal such as aluminum, stainless steel, iron, or gold. Although no limitations are imposed of the metal material, to prevent overheating of a sheet not being conveyed, metals that produce less radiation heat are preferable. The partition member may be a metal plate through which holes are formed, in place of the wire gauze **42**.

The wire gauze **42** serves to divide the inside space (i.e., the space between the confronting openings) of the main frame body **28**. The deep-side one (see FIG. **2**) of the divisional spaces of the inside space is the heating space **30** in which a heater unit **44** is disposed. Having a rod-shaped heating body, the heater unit **44** generates heat by converting electric energy into thermal energy. Since the heater unit **44** is intended to accelerate evaporation and drying of inks by causing them to absorb thermal energy (radiation heat) produced by the heater unit **44**, it is preferable that the radiation energy spectrum of the heating body overlap with the energy absorption spectrum of water. Although an infrared heat is a typical example, the heater unit **44** is not limited to it.

On the other hand, the view's-side divisional space (see FIG. **2**) is the drying space **32** in which a part of the recording medium **12** is conveyed parallel with the opening.

FIG. **3**A shows the drying unit **26** in such a manner that it is rotated clockwise by 90° from the state of FIG. **1**. FIG. **3**B shows a drying unit of Comparative Example (described later) for comparison with the drying unit **26**.

As shown in FIG. **3**A, the inlets **34** and **36** are formed so as to be associated with the drying space **32** and the heating space **30**, respectively, which are separated from each other by the wire gauze **42**. The outlets **38** and **40** are formed so as to be associated with the drying space **32** and the heating space **30**, respectively. That is, the single inlet **34** and the single outlet **38** are provided for the drying space **32** and the single inlet **36** and the single outlet **40** are provided for the heating space **30**.

Because of the structure of the wire gauze **42**, objects that are larger than the holes of the wire gauze **42** cannot move between the heating space **30** and the drying space **32** but gas can move between them. In other words, whereas gas can flow from the heating space **30** to the drying space **32**, no part of the recording medium **12** can move from the drying space **32** to the heating space **30**.

As shown in FIG. **4**A, a backside fan unit **48** is equipped with a base member **50** which closes the heating-space-**30**-side opening of the main frame body **28**. Nine circular holes are formed through the base member **50** as gas blowing holes **52**. It is preferable that the gas blowing holes **52** be formed in such a manner that their centers coincide with the centers of nine rectangular divisional regions obtained by equally dividing the base member **50**. The nine blowing holes **52** may be arranged in a staggered or irregular form.

Nine backside fans **54** which are axial flow fans are attached to the base member **50**. Each backside fan **54** has a structure that blades are attached to a rotary shaft and rotated by driving the rotary shaft by a motor. In the exemplary embodiment, the blade diameter is equal to 100 mm. Each backside fan **54** is attached to the base member **50** in such a manner that its rotary shaft coincides with the center of the blowing hole **52** (circular hole). The nine blowing holes **52** serve as blowing holes for drying winds when the backside fans **54** are driven.

As shown in FIG. **3**A, gas that is supplied from the backside fans **54** flows mainly in such a manner as to be heated as it passes the heater unit **44** (heating body) from its back side to the front side in the heating space **30** and to then reach the wire gauze **42**.

The backside fans **54** are not limited to axial flow fans, and the number of backside fans **54** need not always be equal to nine. Gas flows may be produced at another place and guided to the base member **50** by ducts. each gas blowing hole **52** need not always be circular and may have any of other shapes such as a slit and meshes.

In the exemplary embodiment, a first object of using gas that flows inside the drying unit **26** is to cool, that is, prevent overheating of, the inside of the drying unit **26** (described later in detail). A second object is to remove humid gas from around a target part of the recording medium **12** to assist drying of that part of the recording medium **12** by radiation heat of the heater unit **44**. Therefore, in the following, the gas flow will be referred to as a "drying wind."

The drying unit **26** has, as inlets for drying winds, the inlets **34** and **36** which are formed through the first wall **28**A and blowing holes **52** which are formed in the backside fan unit **48**. On the other hand, the drying unit **26** has, as outlets for drying winds, the outlets **38** and **40** which are formed through the second wall **28**B.

In the drying unit **26** according to the exemplary embodiment, drying winds that are supplied through the inlets **34** and **36** and the blowing holes **52** are blown over an image-formed surface portion of the recording medium **12** being conveyed. As a result, gas containing water vapor that has been evaporated from this part of the recording medium **12** by drying by radiation heat is removed from it.

Main streams of drying winds are formed by drying winds that are supplied through the inlets **34** and **36** and flow parallel with an image-formed surface portion of the recording medium **12** in the direction opposite to the conveying direction of the recording medium **12**, and humid gas produced by drying is discharged through the outlets **38** and **40**. Since drying winds flow in the direction opposite to the conveying direction of the recording medium **12**, their relative flow speeds are increased and hence their ability to remove humid gas is enhanced.

In the drying unit **26** according to the exemplary embodiment in which the heating space **30** and the drying space **32** are separated from each other by the wire gauze **42** is higher in drying efficiency than a radiation heating type drying device in which the heating space **30** and the drying space **32** are separated by a glass plate or a metal plate because thermal energy generated by the heater unit **44** can be used without being wasted partially. In addition, drying winds increase the ability to remove humid gas per unit time.

On the other hand, the fact that drying winds can move between the heating space **30** and the drying space **32** means that paper powder produced from the recording medium **12** in the drying space **32** may go into the heating space **30** while drying is performed. In the exemplary embodiment, this problem is solved by attaching the backside fan unit **48**. That is, the backside fan unit **48** sends necessary drying winds from behind the heater unit **44** through the blowing holes **52**, and thereby stops air flows that would otherwise move from the drying space **32** through the wire gauze **42** and prevents paper powder from reaching the heating space **30**.

Drying winds (air flows) produced by the backside fan unit **48** flow to reach the heater unit **44**, the wire gauze **42**, and the recording medium **12** in this order. Therefore, in an emergency such as a stop of conveyance of the recording medium **12**, drying winds exercise their cooling function, that is, cool the heater unit **44** and the wire gauze **42** and prevent overdrying of a target part of the recording medium **12** due to overheating.

FIG. **4**B shows, by arrows, stream line of drying winds produced by the backside fan unit **48**. In the heating space **30**, drying winds sent through the blowing holes **52** are blown over the heater unit **44** uniformly. As a result, in the drying space **32**, a drying wind sent from the inlet **34** reaches the outlet **38** after going in the direction opposite to the conveying direction of the recording medium **12** without being directed to the heating space **30**.

FIG. **4**C is a chart showing a flow speed distribution characteristic of the backside fan unit **48**. It is seen that there is no speed variations that would cause circulating flows.

Workings of the drying unit **26** according to the exemplary embodiment will be described below.

FIG. **3**A shows a preferable mode in which the opening/closing states of the inlets **34** and **36**, the blowing holes **52**, and the outlets **38** and **40** and the flow speeds of drying winds supplied through the inlets **34** and **36** and the blowing holes **52** are ones obtained by experiments (described later), in the drying unit **26** according to the exemplary embodiment. Since the opening areas of the inlets **34** and **36** and the blowing holes **52** are fixed, flow rates are determined necessarily once flow speeds are set.

FIG. **3**A shows the drying unit **26** according to the exemplary embodiment being in the preferable mode, conditions of which are set as follows:

(Condition 1) The flow speed of a drying wind supplied through the drying-space-**32**-side inlet **34** is 10 m/s.

(Condition 2) The flow speed of a drying wind supplied through the heating-space-**30**-side inlet **36** is 5 m/s.

(Condition 3) The flow speed of drying winds supplied through the blowing holes **52** of the backside fan unit **48** is 1 m/s.

(Condition 4) The drying-space-**32**-side outlet **38** is in a natural opening state in terms of calculation.

(Condition 5) The heating-space-**30**-side outlet **40** is closed.

FIG. **3**B shows a drying unit of Comparative Example which is equipped with no backside fan unit. The drying unit of Comparative Example is the same as the drying unit **26** according to the exemplary embodiment except that no backside fan unit is provided. Therefore, descriptions of the drying unit of Comparative Example are omitted with the use of symbols that are obtained by attaching suffix "P" to the corresponding symbols of the drying unit **26**.

In the drying unit **26**P of Comparative Example, the flow speed of a drying wind supplied through the drying-space-**32**P-side inlet **34**P is 10 to 20 m/s. The heating-space-**30**-side inlet **34** is open to the ambient air. The two outlets **38**P and **40**P are in a natural opening state in terms of calculation.

In FIGS. **3**A and **3**B, drying wind flows that are faster than 4 m/s are indicated by arrows. Whereas clear reverse flows (circulating flows) are found in FIG. **3**B, no circulating flows are found in FIG. **3**A.

Table 1 shows evaluation results, that is, results of comparison between the preferable mode according to the exemplary embodiment shown in FIG. **3**A and Comparative Example shown in FIG. **3**B.

TABLE 1

	Backside fan unit	Circulating flows	Heater cooling effect	Wire gauze cooling effect	Humid air removing effect
Preferable mode	Attached	Occur	High	High	High
Comparative Example	Not attached	Do not occur	Low	Low	Low

As seen from Table 1, in the preferable mode in which the backside fan unit **48** is provided, no circulating flows occur and drying winds do not flow from the drying space **32** to the heating space **30**. Therefore, paper powder produced from the recording medium **12** in the drying space **32** is prevented from going into the heating space **30** being carried by drying winds.

Since the backside fan unit **48** produce downward flows (as viewed in FIG. **3**A) of drying winds, the flow speeds of drying winds at the wire gauze **42** are higher and hence the effect of cooling the wire gauze **42** is higher than in the case without the backside fan unit **48**. Furthermore, because no circulating flows occur, humid air containing water evaporated from a target part of the recording medium **12** is discharged efficiently through the outlet **38**.

When the recording medium **12** undergoes an emergency stop, there may occur an event that stagnant drying winds are heated gradually even if the heater unit **44** is turned off, resulting in overheating of a target part of the recording medium **12**. In the exemplary embodiment, such overheating of a target part of the recording medium **12** is prevented because drying winds produced by the backside fans **54** cool the heater unit **44** and the wire gauze **42**.

(Experiments)

FIGS. **5**A-**5**C to FIGS. **7**A-**7**C show Experiments 1-3 for finding preferable parameter values of the preferable mode of the drying unit **26** (see FIG. **3**A).

(Experiment 1)

Experiment 1 is to check gas flow characteristics in the drying unit **26** for three patterns of combinations of conditions on the drying wind supply side and discharge side. Whether or not paper power goes into the heating space **30** is judged on the basis of presence/absence of drying winds flowing toward the heating space **30**. “Natural opening” is a term of calculation.

TABLE 2

Pattern	Drying-space-side inlet	Heating-space-side inlet	Blowing holes of backside fans	Drying-space-side outlet	Heating-space-side outlet
1	10 m/s	Closed	1 m/s	Natural opening	Natural opening
2	10 m/s	Closed	1 m/s	Natural opening	Closed
3	10 m/s	5 m/s	1 m/s	Natural opening	Natural opening

In Experiment 1, the degree of stagnation of drying winds decreases in order of Pattern 1, Pattern 2, and Pattern 3. One cause of circulating flows is stagnation of drying winds.

As seen from FIG. **5**A, in Pattern 1, no drying wind is supplied through the heating-space-**30**-side inlet **36** and the heating-space-**30** outlet **40** is in a natural opening state in terms of calculation. It is seen that in Pattern 1 stagnation occurs most remarkably though the backside fan unit **48** is provided.

As shown in FIG. **5**B, Pattern 2 is different from Pattern 1 in that the heating-space-**30** outlet **40** is closed. Although Pattern 2 is improved from Pattern 1, stagnation of drying winds still occurs.

On the other hand, as shown in FIG. **5**C, Pattern 3 is different from Pattern 1 in that a drying wind is supplied through the heating-space-**30**-side inlet **36** at 5 m/s. In Pattern 3, the function of the backside fan unit **48** is utilized sufficiently and the degree of stagnation of drying winds is very low.

Evaluation Results of Experiment 1:

In Experiment 1, the degree of stagnation of drying winds (gas) which occurs mainly in the heating space **30** varies depending on the number of inlets and outlets used. It is preferable that drying wind supply be made to both of the heating space **30** and the drying space **32** and drying wind discharge be made only from the drying space **32**.

When a drying wind is supplied through the heating-space-**30**-side inlet **36**, the function of the backside fan unit **48** is utilized sufficiently, as a result of which no circulating flows occur and paper powder is prevented from going into the heating space **30**.

It is concluded that the most preferable mode of Experiment 1 is Pattern 3.

(Experiment 2)

Experiment 2 is to check drying wind (gas) flow characteristics in the drying unit **26** (heating space **30** and drying space **32**) for three patterns in which the flow speed at the heating-space-**30**-side (second supply side) inlet **36** is different. A temperature variation of the wire gauze **42** and whether or not paper power produced in the drying space **32** goes into the heating space **30** are judged. “Natural opening” is a term of calculation.

TABLE 3

Pattern	Drying-space-side inlet	Heating-space-side inlet	Blowing holes of backside fans	Drying-space-side outlet	Heating-space-side outlet
1	10 m/s	2 m/s	1 m/s	Natural opening	Closed
2	10 m/s	5 m/s	1 m/s	Natural opening	Closed
3	10 m/s	8 m/s	1 m/s	Natural opening	Closed

As shown in FIG. **6**A, in Pattern 1 of Experiment 2, whereas the temperature of the wire gauze **42** tends to be higher than a desired temperature, no circulating flows occur.

As shown in FIG. **6**B, in Pattern 2, the temperature of the wire gauze **42** is lower than the desired temperature and no circulating flows occur.

As shown in FIG. **6**C, in Pattern 3, although the temperature of the wire gauze **42** is lower than the desired temperature, circulating flows occur and hence paper powder may go into the heating space **30**.

Evaluation Results of Experiment 2:

Experiment 2 shows that the temperature of the wire gauze **42** can more likely be made lower than the desired temperature as the flow speed at the heating-space-**30**-side inlet **36** increases, and that circulating flows occur (due to shear flows) near the inlets **34** and **36** if the flow speed is too high. It is seen that the flow speed at the heating-space-**30**-side inlet **36** has an allowable upper limit and lower limit. It is concluded that the most preferable mode of Experiment 2 is Pattern 2.

(Experiment 3)

Experiment 3 is to check drying wind (gas) flow characteristics in the drying unit **26** (heating space **30** and drying space **32**) for four patterns in which the flow speed in the backside fan unit **48** is different. A temperature variation of the wire gauze **42** and whether or not paper power produced in the drying space **32** goes into the heating space **30** are judged. "Natural opening" is a term of calculation.

TABLE 4

Pattern	Drying-space-side inlet	Heating-space-side inlet	Blowing holes of backside fans	Drying-space-side outlet	Heating-space-side outlet
1	10 m/s	5 m/s	1 m/s	Natural opening	Closed
2	10 m/s	5 m/s	0.8 m/s	Natural opening	Closed
3	10 m/s	5 m/s	0.5 m/s	Natural opening	Closed
4	10 m/s	5 m/s	0.3 m/s	Natural opening	Closed

As shown in FIGS. **7**A-**7**D, in Patterns 1-4 of Experiment 3, the flow speed of drying winds that are blown out of the blowing holes **52** of the backside fans **54** is 1 m/s, 0.8, m/s, 0.5 m/s, and 0.3 m/s, respectively.

In each of Patterns 1-4, the temperature of the wire gauze **42** is lower than the prescribed temperature and no circulating flows occur that causes paper powder to go into the heating space **30**.

Evaluation Results of Experiment 3:

The flow speed of the backside fans **54** is not a major factor in causing circulating flows. The efficiency of cooling of the heater unit **44** and the wire gauze **42** (including suppression of circulating flows) increases as the flow speed of the backside fans **54** becomes higher. Since the cooling efficiency increases at a lower rate as it comes closer to the upper limit (100%), it is not necessary to be set to an unnecessarily a large value. The cooling efficiency does not vary much in a flow speed range that is higher than 1 m/s. Therefore, the most preferable mode of Experiment 3 is Pattern 1.

(Summary of Results of Experiments 1-3)

The flow speeds of drying winds of the drying unit **26** according to the exemplary embodiment shown in FIG. **3**A are ones determined as a combination of the appropriate values of the preferable modes of Experiments 1-3.

That is, in the drying unit **26** according to the exemplary embodiment, the flow speeds of a drying wind supplied through the drying-space-**32**-side inlet **34**, a drying wind supplied through the heating-space-**30**-side inlet **36**, and drying winds supplied through the backside fans **54** are set to 10 m/s, 5 m/s, and 1 m/s, respectively. The heating-space-**30** outlet **40** is closed and drying winds are discharged through the drying-space-**32**-side outlet **38** (natural opening in terms of calculation). As a result, as shown in Table 1, paper powder is prevented from going into the heating space **30** unlike in Comparative Example. And the effect of cooling the heater unit **44** (heating body) and the wire gauze **42** and the effect of removing humid air (i.e., drying efficiency) are made higher than in Comparative Example.

Although Experiments 1-3 are experiments carried out in such a manner that the conditions other than the one to be checked are set to fixed values, experiments may be done using plural conditions as variables.

(Drying of Narrow Recording Medium **12**S)

In the exemplary embodiment, circulating flows which may cause paper powder to go into the heating space **30** are suppressed with the assumption that the drying-space-**32**-side opening is fully closed by a target part of the recording medium **12**. However, in the case of a recording medium **12**S which is narrower than the drying unit **26**, a target part of it may be dried in a state that the drying-space-**32**-side opening is not fully closed.

FIG. **8**A is a front view (i.e., a view as viewed from the side of the drying space **32**) of the drying unit **26**. The wire gauze **42** and the heater unit **44** (heating body) are exposed except in the region where a target part of the recording medium **12**S passes.

FIG. **8**B shows, by arrows, how drying winds (gas) flow in the case where the backside fans **54** are attached (exemplary embodiment). FIG. **8**C shows, by arrows, how drying winds (gas) flow in the case where the backside fan unit **48** (backside fans **54**) is not attached (Comparative Example).

As seen from FIG. **8**C, in Comparative Example, circulating flows occur over a target portion of the recording medium **12**S and hence paper powder may go into the heating space **30**. On the other hand, in the exemplary embodiment, as shown in FIG. **8**B, occurrence of circulating flows is prevented even over a target portion of the recording medium **12**S and hence entrance of powder into the heating space **30** is prevented.

The foregoing description of the embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, thereby enabling others skilled in the art to understand the invention for various embodiments and with the various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention defined by the following claims and their equivalents.

What is claimed is:

1. A drying device comprising:

a drying unit comprising:

a heating space having a heating unit;

a drying space that has a conveyance path of a recording medium and in which the recording medium is dried by radiation heat produced by the heating unit; and

a partition member that separates the heating space and the drying space from each other in such a manner that gas can move between the heating space and the drying space;

a first supply unit that supplies gas to the drying unit in a direction that is opposite to a conveying direction of the recording medium; and

a second supply unit that supplies gas to the drying unit in a direction from the heating unit to the partition member.

2. The drying device according to claim **1**, wherein the partition member prevents the recording medium from coming into contact with a heating source of the heating unit and has holes that enable sending of gas from the heating space to the drying space.

3. The drying device according to claim **2**, wherein the heating space and the drying space are provided with respective inlets through which the first supply unit supplies gas to the drying unit, and a flow speed at the drying-space-side inlet is set higher than a flow speed at the heating-space-side inlet.

4. The drying device according to claim **3**, further comprising a discharge unit that discharges the gas supplied by the first supply unit and the second supply unit.

5. The drying device according to claim **4**, wherein:

the heating space and the drying space are provided with respective discharge units; and

gas flow states in the drying unit are controlling by setting flow rates and flow speeds of the gas supplied by the first supply unit and the second supply unit and opening/closure of inlets of the first supply unit and the second supply unit and outlets of the respective discharge units.

6. The drying device according to claim **3**, wherein when conveyance of the recording medium in the drying unit is stopped, the gas that is supplied by the second supply unit serves for cooling of the heating unit and the partition member.

7. The drying device according to claim **2**, further comprising a discharge unit that discharges the gas supplied by the first supply unit and the second supply unit.

8. The drying device according to claim **7**, wherein:

the heating space and the drying space are provided with respective discharge units; and

gas flow states in the drying unit are controlling by setting flow rates and flow speeds of the gas supplied by the first supply unit and the second supply unit and opening/closure of inlets of the first supply unit and the second supply unit and outlets of the respective discharge units.

9. The drying device according to claim **2**, wherein when conveyance of the recording medium in the drying unit is stopped, the gas that is supplied by the second supply unit serves for cooling of the heating unit and the partition member.

10. The drying device according to claim **1**, wherein the heating space and the drying space are provided with respective inlets through which the first supply unit supplies gas to the drying unit, and a flow speed at the drying-space-side inlet is set higher than a flow speed at the heating-space-side inlet.

11. The drying device according to claim **10**, further comprising a discharge unit that discharges the gas supplied by the first supply unit and the second supply unit.

12. The drying device according to claim **11**, wherein:

the heating space and the drying space are provided with respective discharge units; and

gas flow states in the drying unit are controlling by setting flow rates and flow speeds of the gas supplied by the first supply unit and the second supply unit and opening/closure of inlets of the first supply unit and the second supply unit and outlets of the respective discharge units.

13. The drying device according to claim **10**, wherein when conveyance of the recording medium in the drying unit is stopped, the gas that is supplied by the second supply unit serves for cooling of the heating unit and the partition member.

14. The drying device according to claim **1**, further comprising a discharge unit that discharges the gas supplied by the first supply unit and the second supply unit.

15. The drying device according to claim **14**, wherein:

the heating space and the drying space are provided with respective discharge units; and

gas flow states in the drying unit are controlling by setting flow rates and flow speeds of the gas supplied by the first supply unit and the second supply unit and opening/closure of inlets of the first supply unit and the second supply unit and outlets of the respective discharge units.

16. The drying device according to claim **14**, wherein when conveyance of the recording medium in the drying unit is stopped, the gas that is supplied by the second supply unit serves for cooling of the heating unit and the partition member.

17. The drying device according to claim **1**, wherein when conveyance of the recording medium in the drying unit is stopped, the gas that is supplied by the second supply unit serves for cooling of the heating unit and the partition member.

18. An image forming apparatus comprising:

the drying device according to claim **1**; and

an inkjet image forming unit that forms an image on a recording medium by ejecting droplets onto the recording medium.

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